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ARTILLERY NOTES

No. 39½

Report of the Coast Artillery Board of August 12, 1915

on

Experimental Mortar Practice

PUBLISHED UNDER SUPERVISION OF THE
SCHOOL BOARD
COAST ARTILLERY SCHOOL

FORT MONROE, VIRGINIA
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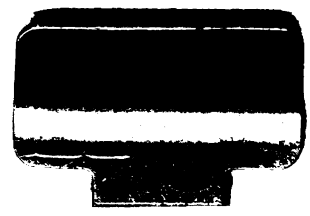
1916



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SCHOOL BOARD
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BY DIRECTION OF THE
CHIEF OF COAST ARTILLERY

FORT MONROE, VIRGINIA
U.S. COAST ARTILLERY SCHOOL ~~PRESS~~
1916

Copy
Maj. T. M. Spaulding
Ord.
11-20-1927

EXPERIMENTAL MORTAR PRACTICE

1. Under date of Dec. 19, 1914, the Coast Artillery Board submitted to the Chief of Coast Artillery an original paper on the subject of mortar ammunition, discussing the points which are summarized as follows:

a. The number of different weights of projectiles now supplied to mortar batteries in our service.

b. The relative unimportance of the 1046-lb. projectile, due to its maximum range being limited to 9300 yards.

c. The increased importance of the 700-lb. projectile with its maximum range limit of 15,600 yards for mortars, Model of 1890.

d. The tactical advantage of having but one weight of projectile, and that one the 700-lb.

e. The unrelated weights of the present mortar charges for the different zones which would prevent the inner-zone charges from being untilized, without remaking, when the outer-zone charges would be exhausted in an action.

f. The tactical advantage that would be obtained by having a series of related charges with the following qualities: that not only should the zone charges increase by equal increments but that they should also have unity for their base, and therefore the property that the combination of two zone charges would give a charge for the zone whose number would be the sum of the two zone numbers; in other words, i.e., that a 6th zone charge plus a 5th zone charge would give an 11th zone charge.

g. That a series of charges as described in (f) for ranges from 5000 to 15,600 yards would give larger zone overlaps than the present system, thus permitting firing with the lower angles of elevation with consequent lower maximum ordinates of trajectories and shorter times of flight, and thereby decreasing the complex atmospheric effects of high altitudes.

h. The value of a test of the system of powder charges recommended by the Board, particularly with a view to eliminating the almost hopeless complexity of the present mortar ammunition service and, thereby, of increasing the tactical advantage of the mortar.

2. The Chief of Coast Artillery gave this proposition of a test his approval and, as a result, it was ordered that the target practice of the Third Fire Command at Fort Monroe,

Va., consisting of 16 mortars manned by the 6th, 35th, 41st, and 168th Companies, should be conducted in a manner to be determined by the Coast Artillery Board and approved by the Commanding Officer, Coast Defenses of Chesapeake Bay, and with the regular annual allowance of target practice ammunition, which was 144 rounds in all.

3. A request of the Board that an Army or Navy hydro-aeroplane be furnished for the test in order to experiment with aerial observation of fire, resulted in a Navy hydro-aeroplane with Lieutenant P. N. L. Bellinger, U. S. N., in charge, being sent here for the test.

4. In accordance with the request of the Board, 50 700-lb. target practice projectiles were furnished, which, with the 22 824-lb. and 72 1046-lb. projectiles on hand, made 144 in all. The following charges of powder were prepared by the Ordnance Department in accordance with the Board's request:

12-INCH MORTAR, MODEL 1890

ZONE CHARGES, DUPONT LOT 14, 1907

Projectiles

Zones 4-10, inclusive, 1046-lb.
" *4-12,* " *824* "
" *6-14,* " *700* "

(Charge consists of weight of smokeless plus one-half the weight of igniter.)

No. of charges	Zone	Charge lbs.	Weight of smokeless lbs.	Weight of igniter oz.
23	1	4.6	4.6	None.
17	2	9.2	9.2	None.
22	3	13.8	13.8	None.
11	4	18.4	17.9	Zones 4 to 14, 6 ounces in each end of charge and 4 ounces in central core.
6	5	23.0	22.5	
11	6	27.6	27.1	
5	7	38.0	37.5	
6	7	32.2	31.7	
12	8	36.8	36.3	
23	9	41.4	40.9	
23	10	46.0	45.5	
17	11	50.6	50.1	
17	12	55.2	54.7	
12	13	59.8	59.3	
17	14	64.4	63.9	
		INTERNATIONAL, LOT 8, 1906		
5	7	38.0	37.5	16 ounces: 4 ounces in central core and 6 ounces in each end.
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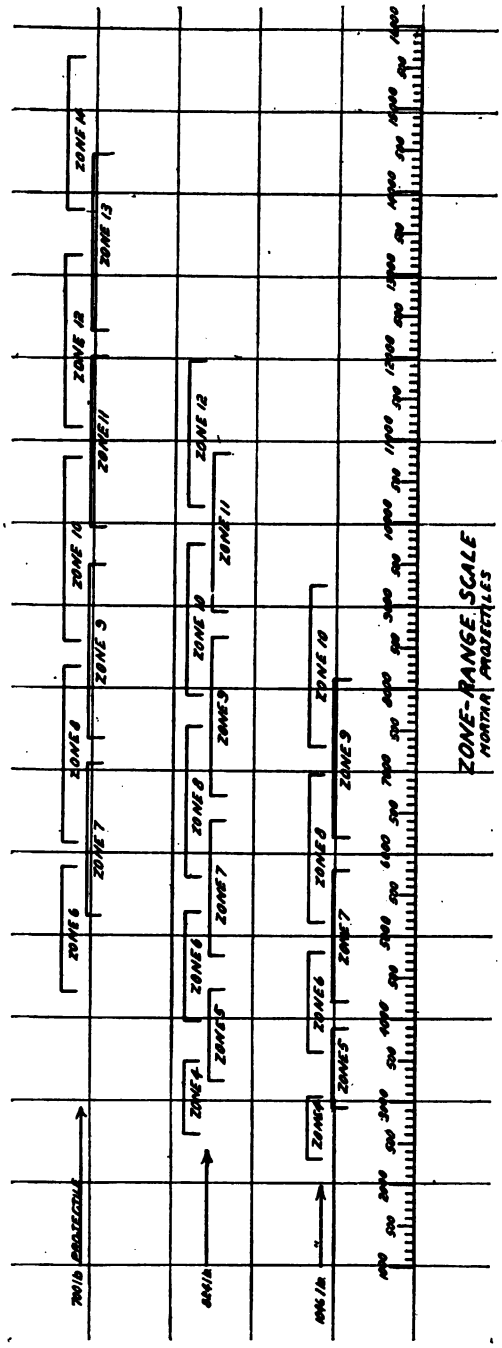

Fig. 1.

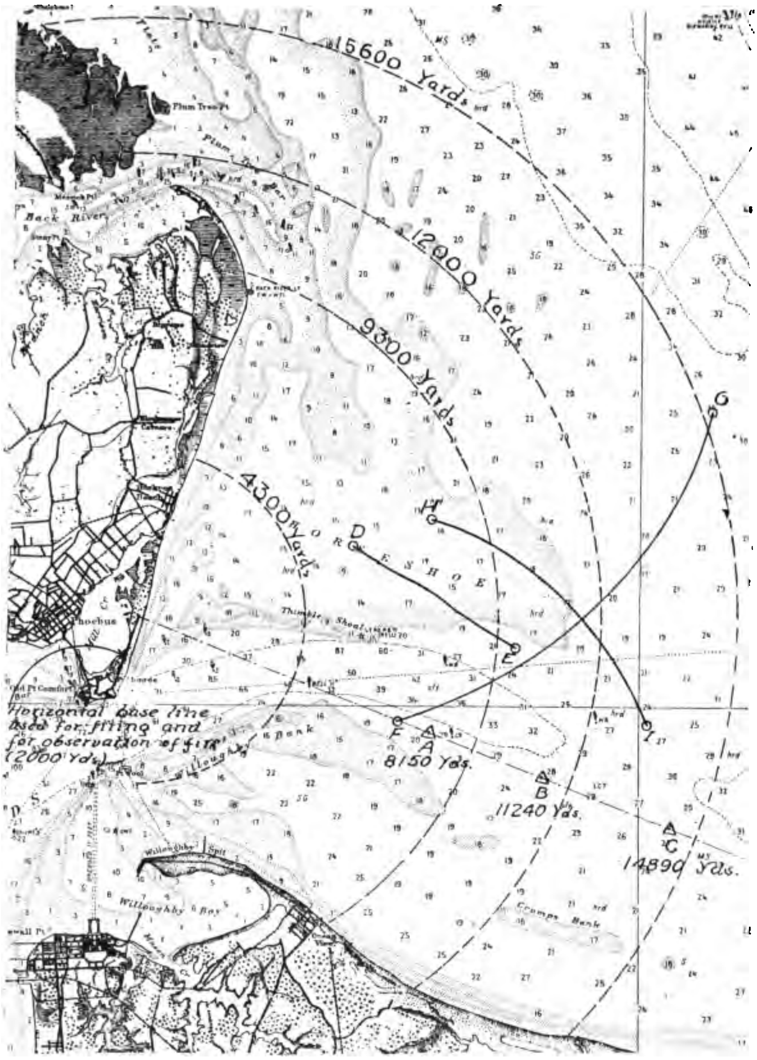
15600 Yards
12000 Yards
9300 Yards
4300 Yards
Plum Tree Pt
Back River
Phoebus
Old Pt Comfort
Thimble Shoal
Horizontal base line used for firing and for observation of fire (2000 Yds)
D
E
F
G
H
I
A
8150 Yds.
B
11240 Yds.
C
14890 Yds.
Willoughby Spit
Willoughby Bay

FIG. 2.

5. It should be stated here that, from a study by the Board of the ballistic data of various powders furnished by the Ordnance Department, the Board was convinced that powders whose web-thickness was between the limits of .055 and .062 inches would be suitable for 1046-, 824-, and 700-lb. projectiles; and, therefore a single series of related charges was determined upon for trial with all three projectiles. For the powder which was furnished and which had an average web-thickness of .058, the range limits of this single series of charges for the three projectiles are shown in Fig. 1.

6. The scale of the battery plotting boards was changed from 1 inch equals 300 yards to 1 inch equals 400 yards, thus giving a maximum range of 18,000 yards. The range-elevation relations were computed for the three types of projectile and were kept on a long strip in a small box on two reels, so that the proper zone-range-elevation relation for any projectile would be displayed at the top by winding the strip from one reel to another. A system of adjustment of fire by instrumental observation of splashes was also devised by Captain A. L. Rhoades, C. A. C., which, briefly, consisted of using the angular difference between splash and target taken at a base-end station and also at the battery; with these angular differences and the approximate azimuth and range of the target as arguments, the over or short and right or left were instantly read in the plotting room from the computations previously made, and used for the correction of fire. The method of applying this correction was one devised by Major E. Landon, C. A. C., and consisted of marking on a movable scale the deviations of splashes with pins, thus enabling the deviation of center of impact to be determined by a glance at the pins.* Subcaliber practice was conducted in this manner with good results. No additional telephone lines were necessary for this observation system, as the intelligence telephone to the base-end station was worn by deflection observer and such commands as the battery commander intended for the base-end observer were transmitted to him by the deflection observer.

7. The test began on August 3 with firing at fixed targets by the 6th Company, C. A. C., in "B" pit, Battery Anderson, as follows:

At a planted pyramidal target at *A* (Fig. 2); for each shot the splash, target, and tug were plotted.

* See *Journal U. S. Artillery* for September-October, 1915—*Editor.*

A. FIFTEEN ROUNDS OF 1046-LB. CAST-IRON PROJECTILES

Round	Zone	Charge	Range	Elevation		Deviation in Yards			
						Over	Short	Right	Left
				°	′				
1	10	10	8150	57	55	221			65
2	10	5+5	8150	57	55	13			65
3	10	3+7[x]	8150	57	55	322			57
4	10	10	8140	58		165			16
5	10	6+4	8140	58			100		16
6	10	3+7[x]	8130	58	5	374			0
7	10	10	8125	58	5	57			33
8	10	7+3	8140	58		18			33
9	10	3+7[x]	8155	57	55	344			8
10	10	10	8110	58	10		31		8
11	10	8+2	8110	58	10		130	8	
12	10	3+7[x]	8115	58	10	342			8
13	10	10	8135	58	5		95		16
14	10	9+1	8120	58	10		38		8
15	10	3+7[x]	8105	58	10	292			0

The rounds were fired in the above sequence in order to obtain as far as possible the same general conditions of atmosphere for the three sets of five rounds each: (1), for single charges; (2), for combinations of the different pairs of the same web-thickness as the single charge; and, (3), for the combination of a third-zone charge of the same web-thickness as the above with the seventh-zone charge, marked 7[x] in above table, of .07 web-thickness.

The following results of this firing are noted:

a. The range-difference of the centers of impact of the series of five using the single 10-zone charges and of the series of five using charges which were combinations of other zone-charges of the same powder, was about 110 yards; that is, the average range of the first series was 62 yards beyond the target and that of the second was 47 yards short. It was to be expected that the single charges, with core igniters, would range farther than the combined charges, but the difference is relatively so small as to warrant the use of the combined charges when the single charges become exhausted.

b. The series of five which used charges one part of which had a different web-thickness from the other gave considerably greater range but they gave a remarkably close group, the maximum range deviation from the mean range being but 41 yards. This would indicate that, though undesirable,

combinations of powders with different web-thickness can be used with proper adjustment of fire.

B. FOUR ROUNDS OF 824-LB. CAST-IRON PROJECTILES AT SAME TARGET

Round	Zone	Charge	Range	Elevation	Deviation in Yards			
					Over	Short	Right	Left
				° ′				
1	9	9	8130	52 50	137			11
2	9	5+4	8100	53 10	19			8
3	9	9	8100	53 10	156		8	
4	9	7+2	8110	53 5	24		24	

This series again shows that the single charge ranged farther but that the difference is comparatively small enough to warrant the use of the combined charges when the single charges are used up.

C. FOUR ROUNDS OF 700-LB. CAST-IRON PROJECTILES AT SAME TARGET

Round	Zone	Charge	Range	Elevation	Deviation in Yards			
					Over	Short	Right	Left
				° ′				
1	9	9	8105	59 5		42	16	
2	9	5+4	8100	59 10		200	40	
3	9	9	8110	59 5		13		8
4	9	7+2	8105	59 5		24	8	

This series indicates that the remark about the preceding group is applicable.

At a planted pyramidal target marked *B*.

A. SIX ROUNDS OF 824-LB. CAST-IRON PROJECTILES

Round	Zone	Charge	Range	Elevation	Deviation in Yards			
					Over	Short	Right	Left
				° ′				
1	12	12	11240	52 5	267			45
2	12	6+6	11260	52		92	45	
3	12	12	11260	52	339			11
4	12	7+5	11260	52	220			22
5	12	12	11225	52 10	272			11
6	12	8+4	11250	52	18			22

The remarks about the two preceding groups are applicable.

At a planted pyramidal target marked *C*.

A. SIX ROUNDS OF 700-LB. CAST-IRON PROJECTILES

Round	Zone	Charge	Range	Elevation	Deviation in Yards			
					Over	Short	Right	Left
				° ′				
1	14	14	14890	50 40		348	223	
2	14	7+7	14875	47 20		15	30	
3	14	14	14890	47 15		20	0	
4	14	9+5	14880	47 20	58			30
5	14	14	14925	46 50		60	15	
6	14	11+3	14890	47 15	35			30

This series indicated that, considering the 500-yard correction applied after the first shot, a remarkably uniform grouping was obtained with the 700-lb. projectile at nearly 15,000 yards range and one independent of whether a single or a combined charge was fired.

If general conclusions may be drawn from the whole series fired at the three planted targets, it can be said:

(1) That with 1046-lb. and 824-lb. projectiles the single charges ranged farther than the combined charges, but that the difference is comparatively small enough to warrant the use of the combined charges when the single charges are used up. The range difference can be compensated for by adjustment of fire.

(2) That the 700-lb. projectile throughout its range, and particularly at long range, showed excellent ballistic qualities with single or combined charges; therefore, where they are most likely to be needed, the combined charges give their greatest efficiency.

The results of "Problem Four" where combined charges were freely used, and even as many as four sections were used for one charge, bear out these conclusions.

Lieutenant Bellinger, U. S. N., was to have taken advantage of these shots in practicing spotting from his hydroaeroplane; but, due to engine troubles, was unable to get much benefit from the practice.

8. The second problem consisted in firing seventeen rounds 1046-lb. cast-iron projectiles in their three outer zones by the 41st Company in "A" pit, Battery Anderson, on August 4, at a moving target which followed the curved course marked *D-E*. The details of this firing are shown in the records and analysis of practice. The following summary is given.

Round	Zone	Range	Elevation ° ′	Deviation in Yards				Remarks
				Over	Short	Right	Left	
1	8	6090	58 10	96			43	First ranging shot.
2	8	6250	57 40	83			0	B′ armsetter made errors.
3 salvo	8	6780	52 20		52		12	
4	8	6780	52 20		9	14		
5	9	7150	58 40		15	11		
6 salvo	9	7650	54 25	67			64	Plotter's error
7	9	7650	54 25	246			39	+130 yards.
8 salvo	9	7660	54 15	80			55	Plotter's error +90
9	9	7660	54 15	27			16	yards.
10 salvo	9	7930	52 00	44		53		
11	9	7930	52 00	132		88		
12 salvo	9	8120	48 30		13		18	
13	9	8120	48 30	21		16		
14 salvo	10	8320	57 40		36		31	Plotter's error and
15	10	8320	57 40		46	29		armament error compensating.
16 salvo	10	8700	54 50	129			29	Plotter's error and
17	10	8700	54 50	242		5		armament error in same direction.

This series was for the purpose of testing the system of observation of fire and its adjustment, in the use of the 1046-lb. projectile in its three outer zones, and therefore with three different weights of charge. The B′ arm-setter, who had done excellent work in drill and subcaliber practice, apparently went to pieces and his errors affected at times not only the track of the target but also the plotter's work in prediction. The records of this practice show, in general, excellent results in the use of instrumental observation of fire for single shots but only fair results in the case of salvos.

On this day the aviator was unable to rise from the water in his hydroaeroplane during the practice.

9. The third problem consisted of firing 36 rounds, 12 700-lb., 12 824-lb. and 12 1046-lb. cast iron projectiles, by the 168th Company in "A" pit of Battery Ruggles on August 5, at a moving target which followed the curved course marked

F-G, both going out and coming in. The details of this firing are shown in the records and analysis of practice. The following summary is given.

Round	Zone	Range	Elevation	Deviation in Yards				Remarks
				Over	Short	Right	Left	
1	10	7945	60 15	24			37	
2	10	8190	57 40	59			34	
3	10	8320	56 50		46	6		
4	10	8455	57 15		103	3		Plotter's error −40 yards.
5	10	8760	54 05	170		23		Correction + 125 yards applied.
6	10	8920	52 25	60		2		
7	11	10190	53 50	358		39		Projectile changed from 1046 to 824 lbs.
8	11	10480	54 20		88		27	Correction − 425 yards applied.
9	11	10695	51 55	42			2	
10	11	10890	50 35	5			8	
11	11	11030	49 45		99	48		Plotter's error −70 yards.
12	11	11280	45 30		21	35		
13	11	11710	52 40		76		8	Projectile changed from 824 to 700 lbs.
14	11	11930	48 10	62			31	Correction + 250 yards applied.
15	12	12080	45 35	37			34	
16	13	13440	53 50	72		28		
17	13	13710	53 10		61	60		
18	13	14070	50 10		29	8		
19	14	15470	49 30		328		486	First shot in 2d series and fired at predicted point by mistake.
20	14	15140	49 25	71		45		

Round	Zone	Range	Elevation ° ′	Deviation in Yards				Remarks
				Over	Short	Right	Left	
21	14	14710	53 10	29		15		
22	13	14515	46 25		137	38		
23	13	14380	47 30		150		12	
24	13	14100	47 35	51			30	Correction + 30 yards applied.
25	12	11630	47 35	213			2	Change of projectile from 700 to 824 lbs.
26	12	11380	53 55	85			12	Correction − 380 yards applied. Plotter's error +50 yards.
27	11	11125	47 50	35			126	Deflection board operator's error 135 yards left.
28	11	11000	51 45		137	0	0	Mistake in using observation of fire −200 yards.
29	11	10860	53 00		81		13	Same error as No. 28.
30	11	10735	54 30		246		13	Same error as No. 28.
31 salvo	10	8865	56 25		563		50	Change of projectile
32	10	8865	56 25		563		32	from 824 to 1046 lbs.
33 salvo	10	8490	53 25	140			33	Correction +650
34	10	8490	53 25	147			33	yards applied.
35 salvo	10	8220	57 35	33			3	Correction +150
36	10	8220	57 35	48		6		yards applied.

This series was for the purpose of introducing the various questions that might arise in connection with firing at a moving target under tactical orders from the fire commander, and involving prompt changes of charges and projectiles. This series is probably unique in our mortar firing, for it involved the use of 1046-, 824-, and 700-lb. projectiles with their proper zone charges for two series of firings at a moving target on curved courses and at ranges which varied from 7945 yards to a maximum of 15,470 yards. There was no difficulty in the service of charges or projectiles, the latter being arranged on skids in the pit. The fire-control section was overworked and on account of shock and stress the individuals did not

perform their separate functions as well as in their drills and subcaliber practice. Such firings as these form the only reliable basis for estimating the accomplishment that may be expected in actual service. Attention is particularly called to the adjustment necessary when projectiles are changed and to the serious effect this might have at a critical stage of an action. This series also included for the first course aerial observation of fire from the hydroaeroplane.

On this day Lieutenant Bellinger made an excellent flight in his hydroaeroplane. He was unable to rise with his assistant, Lieutenant. Spencer, so alone he flew at considerable height over the target; and, as the splashes of the shots were made in the water he reported their fall by means of firing black smoke shells from a Very pistol—one over and two short: these were observed instantly at the battery and at the fire commander's station, and reported to the battery commander. About three of his series of eighteen signals could not be made out, but the others were in accordance with the result of the instrumental observation. Lieutenant Bellinger was, in addition, estimating the amount of overs and shorts and recording them, but after several records his pencil was blown from his mouth by the wind, and his record could not be completed. When it is remembered that this series of firings included ranges up to 15,470 yards from the battery, it will be seen how valuable even this information would have been if the instrumental observation could not have been made; this could easily have happened if the air had not been so clear. Lieutenant Bellinger's act in performing through professional zeal this function in addition to his hazardous duty under the best of conditions, certainly deserves commendation.

10. The fourth problem consisted of firing 47 rounds: 28 700-lb. and 19 1046-lb. cast-iron projectiles, by the 35th Company, C. A. C., in "A" pit, Battery Ruggles, August 6, at moving targets towed by the steamers *Wetherill* and *Reno* on the curved courses marked *F-G* and *H-I*. It was planned in this series to undertake the full problem of mortar fire by requiring the Battery Commander not only to fire in different zones with at least two different projectiles but also to change targets at such times as would require him to use different charges and projectiles from those with which he would be conducting his fire when the order to change should be received. The plan was carried out to include firing at different towed

targets but a prompt change from one target to another could not be made, owing to the failure of the radio set on the *Wetherill* to receive the Fire Commander's message sent from the radio station at Fort Monroe at a distance of about 14,000 yards.

The details of this firing are shown in the records and analysis of practice. The following summary is given.

Round	Zone	No. of bags	Range	Elevation ° ′	Deviation in Yards				Remarks
					Over	Short	Right	Left	
1	10	1	9530	57 50		102		74	First shot, 700-lb. projectile.
2	10	1	9615	56 15	48			110	Error on deflection board.
3	10	1	10050	47 30	323		53		
4	11	1	10720	57 20		125		3	Correction of −220 applied.
5	11	1	11040	55 10		54	57		Correction of +70 applied.
6 salvo	11	1	11380	53 00	27		39		
7	11	2	11380	53 00		230	49		No error found.
8 salvo	11	2	11640	51 00	50		69		Error on deflection
9	11	2	11640	51 00		76	81		board.
10 salvo	12	1	12070	55 00		25		98	Error on deflection
11	12	1	12070	55 00	5			73	board.
12 salvo	12	1	12180	54 25		132		53	
13	12	1	12180	54 25		2		21	
14	9	1	7880	51 15	53		89		First shot, 1046-lb. projectile.
15	10	2	8370	56 45		104	109		Error on deflection board.
16	10	2	8550	54 25	48		83		Error on deflection board.
17	10	2	8950	51 25		55	46		
18	10	2	9060	50 00	5		71		Error on deflection board.
19 salvo	10	2	9740	55 40	40			135	Projectile changed
20	10	2	9740	55 40	22			110	to 700-lb.
21 salvo	10	2	9750	55 40		222		111	Error by plotter.
22	10	2	9750	55 40		33		77	Error on deflection board.

Round	Zone	No. of bags	Range	Elevation ° ′	Deviation in Yards				Remarks
					Over	Short	Right	Left	
23	10	2	9870	54 40	48			78	Error on deflection board.
24	10	2	10050	53 50		270	70		Error on deflection board.
25	13	1	12400	57 40		170		32	Error by plotter.
26	13	1	12520	57 40		570	131		Error on deflection and elevation board.
27	13	1	12770	56 40		518	56		Error on deflection and elevation board.
28	13	1	12930	56 10		450	113		Error by plotter and on deflection board.
29	13	1	13100	55 25		434	45		No cause found.
30	13	1	13200	48 15	1100		57		Error on elevation board, — wrong zone.
31	13	1	13330	53 20		72	139		Error on deflection board. Correction of +250 applied.
32	13	2	13445	51 55	128			105	Error on deflection board. Correction of +150 applied.
33	13	2	13510	52 55		42		152	Range correction of −80 applied.
34	10	2	8680	54 10		41	60		Projectile changed to 1046-lb.
35	10	2	8570	54 30		50		30	
36	10	3	8410	55 30	87			58	
37 salvo	10	3	8260	56 40		29	7		
38	10	3	8260	56 40		78	204		Error of 1° in laying mortar.
39 salvo	10	3	8160	57 10	145			7	
40	10	3	8160	57 10			7		
41 salvo	10	3	8100	57 30		18		16	
42	10	3	8100	57 30	25		0	0	
43 salvo	9	3	7800	52 00	74			6	
44	9	4	7800	52 00	76			2	

Round	Zone	No. of bags	Range	Elevation ° ′	Deviation in Yards				Remarks
					Over	Short	Right	Left	
45 salvo	9	4	7650	54 20		73		24	
46	9	5	7650	54 20		10	0	0	
47	9	3	7400	56 40		133		8	

It is apparent at a glance that a great many errors were made in the range section, and the cause of these errors deserves consideration. Such errors are rarely seen at drill, subcaliber, or ordinary target practice, and the work of this Company during the entire drill season was excellent. This practice was out of the ordinary. A strain was placed on the whole battery such as it had never borne before and one which only an unusually difficult practice or an action could bring out. The range section was overworked and could not shake off the feeling of the great responsibility which rested upon it. These are human failings and they are bound to be met in action, which is the true object of our training. On the other hand, the pit and ammunition sections worked well in spite of the added burdens, which were due to changes in projectiles, the combinations which had to be made to supply powder charges, and changes in these charges due to relays. No error was made in this service, although this problem purposely involved using what was left from the three previous firings. The effect of such firing acts in entirely different ways on men engaged in mental work and men engaged in physical work. The former are strained and depressed, while the latter are decidedly stimulated. The ammunition service depended entirely upon the tactical orders received from the Fire Commander: as a result, nine 1046-lb. projectiles out of the total 144 could not be fired, as only 14th zone charges remained. Artificial conditions were not imposed by the Fire Commander and the problems were permitted to take their natural course.

On this day Lieutenant Bellinger was unable to rise from the water with his hydroaeroplane although he was continually attempting to do so during the practice. It would have been very interesting if he could have got into the air for he had planned to signal one shot over, two short, and, after a slight interval, a number of shots which would have indicated one, within 100 yards; two, within 200 yards; and so on.

General Conclusions and Recommendations

1. The single series of related charges is satisfactory and reduces a hopelessly complex ammunition service to one which is practical and efficient.

2. The 700-lb. projectile with its range limits from 4300 yards to 15,600 yards for the mortar, Model of 1890, is the most important one for our service, and, in the reassignment of mortar projectiles, should be treated accordingly.

3. The single series of related charges enables the change from one projectile to another to be made without confusion at the battery. A new problem of fire adjustment, however, is introduced every time a change of projectile is made.

4. The powder was actually served from the magazines in the emplacements and there was considerable shock in the powder magazine; it would have been almost impossible, on account of shock, for men to have served projectiles from the projectile galleries. It would have been actually impossible to have served them from there, due to the restricted space, without delaying the firing.

5. The mortars and carriages stood the test of long-range firing satisfactorily. The equalizing pipe in No. 3, "B" pit, Battery Ruggles, pulled apart at the center coupler; and the one in No. 4 of the same pit, leaked. The new electric firing circuits proved satisfactory with the exceptions:

a. The contact jaws in the box attached to the left-hand side frame needed continual adjustment to establish continuity of circuit.

b. The milled head screw binding the conductor to the lug on the breechblock would unscrew, due to shock.

These matters should be given consideration by the Ordnance Department.

6. The shock of discharge affected the operation of the zone signal lights.

7. Longer horizontal base lines are needed for firing at targets at such ranges as 15,000 yards, and for the mortar batteries at Fort Monroe supplementary stations on the reservation at Willoughby Spit should be provided. The

adoption of the plotting board which has been devised and tested by the Coast Artillery Board will enable instant changes of base lines to be made.

8. The plotting room is the brain of the mortar battery and should be in a thoroughly protected place. In addition to their lack of protection, those at Batteries Ruggles and Anderson are affected by the shock of salvo discharge.

9. On August 3 a correction of about +500 yards was necessary in firing at the 14,600 yard fixed target with 700-lb. projectile, and two days later an opposite correction of −200 yards was necessary in firing at the moving target at about the same range with the same powder and projectile; this is evidence that the atmospheric changes produce range and deflection deviations that can seriously affect the accuracy of fire. The best means now available to correct for such deviations is by the use of instrumental observation of fire, and this question is not as simple as it seems at first thought. For instance, the records of these firings show that even with the short base lines used, quite accurate results were obtained for single shots; while, for salvos, in many cases poor results were obtained. Far different results might have been obtained if even one observing station could have been advantageously located, for instance, at Willoughby Spit. Future experiments may show improvement in this direction or that more accurate results will be obtained by observing single shots, whether fired singly or in salvos with one shell having a tracer or loaded with a different explosive which bursting in action on impact will give a characteristic color to its smoke. Experimental firing with tracers or loaded shell at fixed targets would probably give some very interesting information on this subject.

10. The fact that in the whole Army and Navy combined but one hydroaeroplane was available for this experiment, and that not only could it not rise at all with two officers but even with the greatest difficulty with one, in spite of the well-known efficiency of the aviator, Lieutenant Bellinger, U. S. N., is a sad commentary on our aerial prepardeness. It is indeed fortunate that Lieutenant Bellinger could get in the air on August 5 and demonstrate so skillfully what even one man could do in the matter of aerial observation of fire. It was really too much for one man to handle the aeroplane, keep out of the line of mortar fire, watch the water constantly for splashes, estimate the distance from the target, fire signals,